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Prospects of renewable energy penetration in Uzbekistan—Perception of the Khorezmian people

Bahtiyor R. Eshchanov [a,*], Mona Grinwis Plaat Stultjes [a], Ruzumboy A. Eshchanov [b], Sanaatbek K. Salaev [b]

[a] Faculty of Economics, Social and Political Sciences and the Solvay Business School, Vrije Universiteit Brussels, Pleinlaan 2, 1050 Brussels, Belgium
[b] Urgench State University, Khamid Alimjan Street 14, Urgench, 220100 Khorezm, Uzbekistan

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ABSTRACT

The energy sectors of fossil fuel-rich Kazakhstan, Turkmenistan and Uzbekistan are heavily dependent on non-renewable resources. The abundance of these resources acts as an obstacle in the process of energy sector diversification in the Central Asian states. The future diversification of energy sources is, however, an inevitable process for many reasons: man-made climate change, the need for transition to reliable and secure energy sources and availability of a vast potential for renewable energy generation being the most important.

The current article investigates the decision-makers′ perception on introduction of renewable energy sources in the residential sector of Uzbekistan using a survey-based analysis. The findings indicate that the possibility of becoming independent from the centrally supplied natural gas and electricity grid and availability of state funded financing are the three main drivers of renewable energy penetration while the higher price of energy from the renewable energy sources acts as a major disincentive. It is also revealed that the residents of urban type multi-storey houses have relatively very small opportunities for renewable energy application due to the smaller surface of their rooftops and also due to lack of sufficient surface in the neighborhood.

Contents

1. Introduction

In line with techno-economic feasibility, social acceptance of the renewable energy sources by the population is of major importance in renewable energy penetration. In Uzbekistan,

* Corresponding author. Tel.: +32 488343043.
E-mail addresses: b.eshchanov@gmail.com, bahtiyore@yahoo.com (B.R. Eshchanov).

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where people are less familiar with the available renewable energy sources and their potential, it is important to find out what are the incentives and disincentives for renewable energy applications. While studying the social acceptance of renewable energy sources in Uzbekistan, some other general aspects should also be kept in mind.

The energy sectors of fossil fuel-rich Kazakhstan, Turkmenistan and Uzbekistan are heavily dependent on non-renewable resources. The abundance of these resources acts as an obstacle to the process of energy diversification. The future diversification of energy sources is an inevitable process due to many reasons: man-made climate change, the need for transition to reliable and secure energy sources and availability of a vast potential for renewable energy generation being the most important.

The impact of climate change in Central Asia can already be observed in the increasingly frequent climate anomalies such as high deviation from the historical average in precipitation levels, increased droughts and unusually harsh winters. These anomalies cause even more disturbing problems such as energy crises during the winters [1] Moreover, they also increase energy consumption, which, as mentioned above, is highly based on fossil fuels, thus creating a chain cycle. Therefore, renewable energy penetration in Central Asia is one of the central questions of energy sector reform and, hence, sustainable development.

Not mentioning the social acceptance, even the potential of renewable energy sources is one of the less investigated areas in these fossil fuel-rich countries. A technical feasibility study of the off-grid renewable energy resources in Uzbekistan carried out by the International Resource Group (IRG) in 2005, concluded that small-scale hydropower facilities were the most feasible off-grid energy options for Uzbekistan for that period [2]. The study was a report prepared for the Ministry of Agriculture and Water Resources of the Republic of Uzbekistan and did not focus on assessing the socio-economic feasibility of individual, household level (residential) renewable energy application.

Worldwide experience demonstrates that residential sectors use a high share of renewable energy. Since the share of residential energy consumption is high with 39% in the total energy consumption [3], Uzbekistan also has an immense potential for introducing renewable energy, especially in the residential sector. It is known that renewable energy generation facility or installments sometimes require a large space or surface which creates additional barriers for its introduction. This problem can still be valid for the residents of multistorey urban houses in Uzbekistan which accommodate ca. 20–25% of the total population (another 10–15% of urban residents live in a private apartment). However, rural residents, who represent 65% of the population, live in remotely located rural residential settlements with lower population density. Around 1.5 million people living in the ca. 1500 remote settlements do not have access to energy infrastructure while the maintenance costs of the existing distribution infrastructure is very high. However, renewable energy penetration did not occur in Central Asia despite continuous energy undersupply [4] and climate change induced winter anomalies. What are the factors that stifle or stimulate household level renewable energy penetration in Central Asia? What conditions have to be met and what can be done to diversify the energy sector through residential renewable energy penetration? Current paper attempts to address these questions.

Khorezm region of Uzbekistan is an appropriate representative of the country both in terms of urban and rural population share [5], average family size [6] and relative population density [7]. Although the income of the population is lower than the income of the European people, it does not vary significantly within the country. Similar studies in the European continent demonstrate that external financing is crucial for renewable energy introduction. The European Renewable Energy Council (EREC) indicates investment subsidies and credits as an important supporting tool for renewable energy application [8]. Grants and credits are the commonly used tool all over the world. The countries interested in expanding the share of renewable energy sources are also known to implement legal frameworks with support mechanisms that create the necessary framework to attract investments in renewable energy. Creating investment subsidies and/or crediting renewable energy penetration are also an important issue for Uzbekistan.

Painuly [9] lists barriers to renewable energy penetration such as: (i) market failure; (ii) market distortions; (iii) economic and financial barriers; (iv) institutional barriers; (v) technical barriers; and (vi) social barriers. All these obstacles are present in Central Asia, where the price of energy supply is one of the lowest in the world. However, the present study concerns itself only with yet unidentified aspects of residential renewable energy penetration such as social acceptance of renewable energy sources. The present study focuses on disclosing how the Uzbek people perceive the domestic application of renewable energy sources.

The study of the application of renewable energy sources in the residential sector in Western countries revealed that social aspects of renewable energy source application are at least as important as their techno-economic feasibility aspects. For example, Wolsink [10] discovered that citizens in European countries demonstrate high public support for renewable energy, which can be explained by the people′s concern about the dependence of European economies on imported fossil fuels and their willingness to pay more for the benefit of environmental sustainability. The views of the people in developing countries, where national income is lower and environmental awareness is less developed, is expected to be different. However, there may also be some other factors furthering renewable energy penetration in the developing countries.

Investigating the demand for green energy in Texas, Zarnikau [11] concluded that informed dialog about energy alternatives results in broader interest and support for these resources. Public discussion of decision-making on alternative energy resources was also found to be particularly important for certain types of alternative energy sources such as wind, biogas and biomass, the generation facilities of which affect the day-to-day lives of citizens in the neighborhood due to their appearance, noise, odor, risk of explosion, etc. Thus, people′s concerns about these factors also need to be investigated.

By surveying the ideas of the Swedish people, Johansson and Laike [12] found that involving the surrounding public in the decision-making process of installing a new wind power plant is more important for the people than the benefit of these wind turbines on the quality of their daily lives. Interviewed people were against the installment of wind power due to its esthetic impact on the environment and recreation, while minor importance was attached by them on the effects of wind turbines on their daily quality of life. Similarly, the present paper also aims to survey the importance of public opinion for decision-making.

Investigating the relationship between willingness to pay for renewable energy and three main factors: (i) environmental concern; (ii) knowledge on renewable energy; and (iii) consequences of renewable energy application, Bang et al. [13] revealed that emotionally charged decisions are more important than facts and knowledge-based decisions among US citizens. It must be questioned whether this is also the case in the developing countries, where people are not sufficiently familiar with the availability and techno-economic feasibility of renewable energy, or whether, on the contrary, lack of knowledge itself is the stifling factor for individual decision making.

Kılınç et al. [14] used a closed form questionnaire to probe the ideas of Turkish students about the characteristics of renewable

energy, its perceived advantages and disadvantages, and their views about the importance of the characteristics of energy production. Authors expected that the combination of such beliefs could act as incentives or disincentives to the acceptability of renewable power in the future, when the generation of these students would become real decision makers. The authors concluded that the belief that renewable power could produce a reliable supply of electricity and, encouragingly, that it could contribute to a reduction in global warming, would be persuasive arguments for its implementation. Again, it should be tested if the perception of real decision makers in developing countries is similar, or if there are other driving forces which could serve as an incentive for residential renewable energy penetration.

In order to investigate these factors, a modified version of the questionnaire developed by Kılınç et al. [14] was used to explore people′s views about the characteristics of renewable energy production, its perceived advantages and disadvantages, and, separately, their views about the importance of various characteristics of energy production in general. Based on the literature consulted, modifications were made to include key factors such as the importance of knowledge [13], consumption efficiency [11], availability of external financial support and reliance on renewable energy [8] (i.e., whether renewable energy sources can fully replace both electricity and natural gas or not). Negative ideas about the characteristics of renewable energy are expected to serve as a disincentive while positive ideas could serve as an incentive for residential renewable energy application.

2. Methodology

The questionnaire used by Kılınç et al. [14] for the identification of the perception of household members on renewable energy served as the basis for the questionnaire adapted to survey the perception of the population in the Khorezm region. According to the official statistics of 2009, 1.4 million people lived in 239,796 households in the Khorezm region. When assuming a 5% margin of error, ca. 780 random households would need to be surveyed, which would have put a heavy claim on the means and resources available. Yet, given the rather similar level of knowledge and awareness among the population on alternative energy sources due to the strict control of the Central Government on information provision, the mindset of the population is quite homogeneous [15]. Furthermore, when also considering that socio-cultural values have to a far extend been master-minded by authorities, 150 randomly chosen households were interviewed assuming that the scope of perception would have been captured in any case. Since the perception of rural and urban households was hypothesized to be different because livelihood activities differ significantly, and which impacts on decisions, the share of rural–urban (95–55 respondents, respectively) population has been kept. It should be acknowledged that statistically 150 respondent corresponds to an accepted error margin of 50%.

For the final selection of the households interviewed, a semi-manual procedure was applied since a complete and reliable listing of inhabitants and addresses were not available for the study region. Therefore numbers were appointed to (a) cities or districts (12 options) and (b) streets or villages (200 options only, since street names and house numbers also lack in the rural areas). Then a set of 150, 2-digit (1–12) and 3-digit (1–200) random numbers have been generated. To complete the random selection of the 55 urban respondents another random vector of 1–200 had been generated for house numbers. For the rural households, households have been selected on the location when the enumerators had reached the random village in a random district.

Section A of the questionnaire included questions on the age, gender and position in the family.[1] The respondents′ willingness to pay a premium for energy from renewable sources and whether they would wish to live close to a renewable energy generation facility such as solar PV stations, small scale biogas and biomass power generators, were asked in the same section. Additional questions were asked in order to draw a broader picture of the situation, which included the average weekly hours of electricity cut-offs in their area and whether the respondents have seen an operating renewable energy plant in their neighborhood.

Section B of the questionnaire probed the respondents′ ideas about various characteristics, advantages and disadvantages of renewable energy generation. The section consisted of 14 items, the first item being "Substantial knowledge on the application of renewable energy (solar, wind, biogas, biomass) sources is required for its successful application in the household". The responses available for all the items in this section took the form of a Likert-scale ('Strongly agree', 'Agree', 'Neutral' (Neither agree nor disagree), 'Disagree' and 'Strongly disagree').

Section C of the questionnaire probed the respondents′ views about the importance of various characteristics of power generation in general and included 11 items. The first item was "How important is it to you that people need to know more about the various aspects of the energy options they have?" and the four available responses were, as for all the other items of this section, 'Very important', 'Quite important', 'Not very important' and 'Not important at all'.

Section D contained five items and explored people′s views about global warming. The first of these items asked the respondents how worried they were about the effects of global warming on the environment. The responses available were 'I am very worried', 'I am quite worried', 'I am a little bit worried' and 'I am not worried at all'. The second item asked the respondents how much they thought they knew about global warming, with the responses available being 'I know a lot about Global Warming', 'I know something about Global Warming', 'I know a little about Global Warming' and 'I know almost nothing about Global Warming'. The third question in this section asked how environmentally friendly respondents considered themselves to be, with 'I am very environmentally friendly', 'I am quite environmentally friendly', 'I am a bit environmentally friendly', and 'I am not at all environmentally friendly' as available responses. The final questions asked whether responders believed that global warming is really happening now; 'I am sure Global Warming is happening', 'I think Global Warming is happening', 'I don′t know whether Global Warming is happening or not', 'I think Global Warming is not happening' and 'I am sure Global Warming is not happening' being the available responses. The survey was conducted in Uzbek and both Uzbek and English versions of the questionnaire are given in the Appendix A.

The cover page included information about the research being carried out and the confidentiality of the respondent′s individual answers. The survey was conducted during two weeks of March 2011, by a professional group visiting randomly selected houses of respondents who voluntarily decided to participate. The STATA 11 statistical package was used to analyze the results.

At this point, it should be acknowledged that Likert scale data and survey based perceptions studies are criticized by some searchers for being "general" or "vague" [12]. Transforming Likert-scale responses into interval-scale variables and computing averages and products is statistically impermissible. However, based on the literature review, it was found that many renewable

[1] The aim of the question on position in the family (head of the family or not) was to clarify if the respondent is a decision maker, and was not a gender analysis.

energy perception surveys applied this technique for their study in order to draw conclusions [12,14].

3. Results

The interviewers explained the purpose of the questionnaire. They have also given a brief description of the available renewable energy sources focusing on the solar, biomass, biogas and wind power generation facilities. The total number of respondents surveyed was 150, with 95 rural and 55 urban participants. Special importance was given to the role of the respondent in the family and only the heads of the families, i.e. 'decision makers' available in the household were interviewed. The unequal gender share of the respondent is due to this aspect and results in 32% and 68% for female and male respondents respectively. Fig. 1 summarizes the age of the respondents.

Furthermore, respondents emphasized the problems regarding the reliability of their residential electricity supply. Fig. 2 summarizes the weekly average electricity cut-offs in the respondents′ homes. Only two of the respondents indicated that they did not have systematic electricity cut-offs and 10 respondents had more than 30 h of electricity cut-offs per week. Average daily cut-off hours corresponded to 1.5 h a day, while maximum daily cut-offs reached 5 h a day.

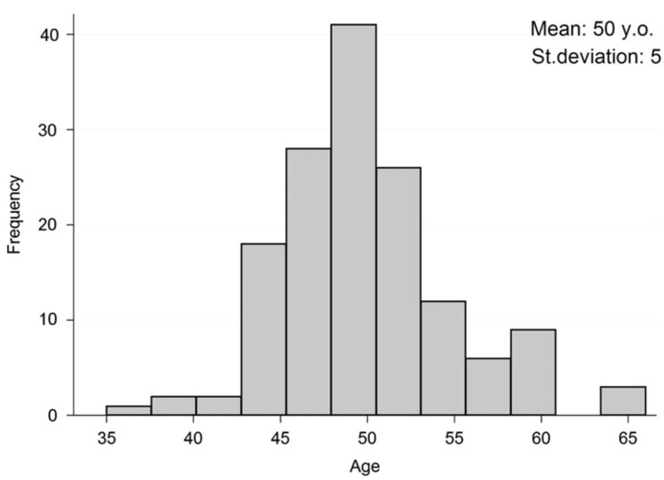


Fig. 1. Frequency histogram of the age of the respondents.

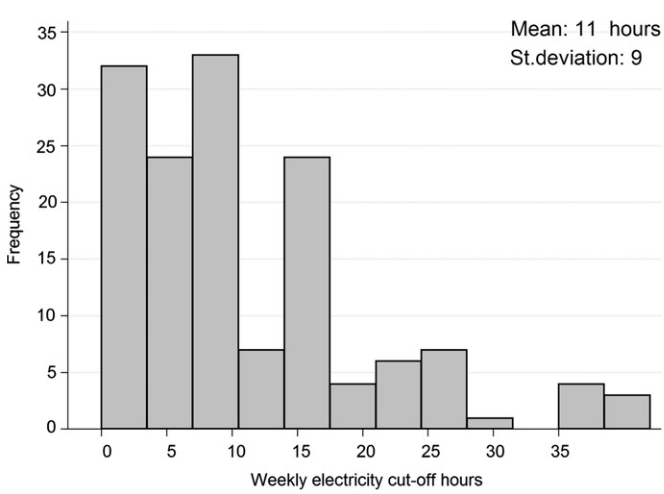


Fig. 2. Frequency histogram of weekly average electricity cut-offs.

According to the responses to an additional question, about 55% of the respondents answered that they were ready to pay a premium for electricity from a renewable source and 75% of the respondents were ready to pay more for electricity from a renewable source if everyone else would be doing so. The amount of the premium was not specified in the questionnaire. Some 60% of the respondents answered that they would not agree with the construction of a renewable energy facility close to their house; however, about 90% of the respondents admitted that they did not have any firsthand experience of how a renewable energy facility works.

As for global warming, 60% of the respondents thought that they knew at least something about global warming, while people who knew 'a lot' and 'little' amounted to 25% and 15% of respondents, respectively. People who were 'sure that global warming is happening' consisted of 54% of the sample while 41% of the respondents thought that 'it is happening' and some 5% were 'not sure whether it was happening or not'. About 52% of the respondents considered themselves 'quite environmentally friendly', 44% claiming to be 'very environmentally friendly', while the figures for 'a little bit' and 'not at all environmentally friendly' were 3% and 1%, respectively. Furthermore, 52% of the respondents were 'very worried', 45% were 'quite worried' and only 3% were 'not very worried' about the harm caused to the environment due to global warming.

3.1. *Perceptions about the characteristics of renewable energy*

Fig. 3 illustrates the respondents′ ideas about the characteristics of renewable electricity generation. The results are ordered from the highest to the lowest share of responses corresponding to respondents who 'Strongly agree' (on the right-hand side). Thus, the black right-hand bar shows the share of the respondents who 'strongly agreed', the next gray bar represents the share who 'agreed', the white bar denotes the 'neutral' respondents (neither agreed nor disagreed), the left gray bar corresponds to respondents who 'disagreed' with a given statement and finally, the black bar shows the share of respondents who 'strongly disagreed'.

About 50% of the respondents 'strongly agreed' and 45% 'agreed' that knowledge of how the potential for renewable energy can be utilized is crucial for its application (Knowledge). Some 33% of respondents 'strongly agreed' that renewable energy sources can replace both electricity and natural gas (Replace traditional sources), creating independent off-grid energy generation for their neighborhoods, while 5% 'disagreed' with this point.

The black right-hand bar shows the share of the respondents who 'strongly agreed', the next gray bar represents the share who 'agreed', the central white proportion denotes the 'neutral' respondents (who neither agreed nor disagreed), the gray bar to the left corresponds to respondents who 'disagreed' and the black left-hand bar denotes the share of respondents who 'strongly disagreed'.

Around 31% of the respondents 'strongly agreed' and some 50% 'agreed' that public discussion is required for renewable energy application in a certain neighborhood (Public opinion). Some 25% of the respondents said that renewable energy application is not viable with their own funds and 'strongly agreed' that getting a loan or credit is a prerequisite, while 56% 'agreed' on this point (Credit availability). About 23% of respondents 'strongly agreed' and 51% 'agreed' that renewable energy sources guaranteed a continuous energy supply (Continuous supply). About 21% of the respondents 'strongly agreed' and 66% 'agreed' on the point that electricity generated with renewable energy sources is cheaper compared to the other sources (Cheaper to make). Around 16% of respondents 'strongly agreed' and 41% 'agreed' that renewable energy sources help combat global warming (Reduce global

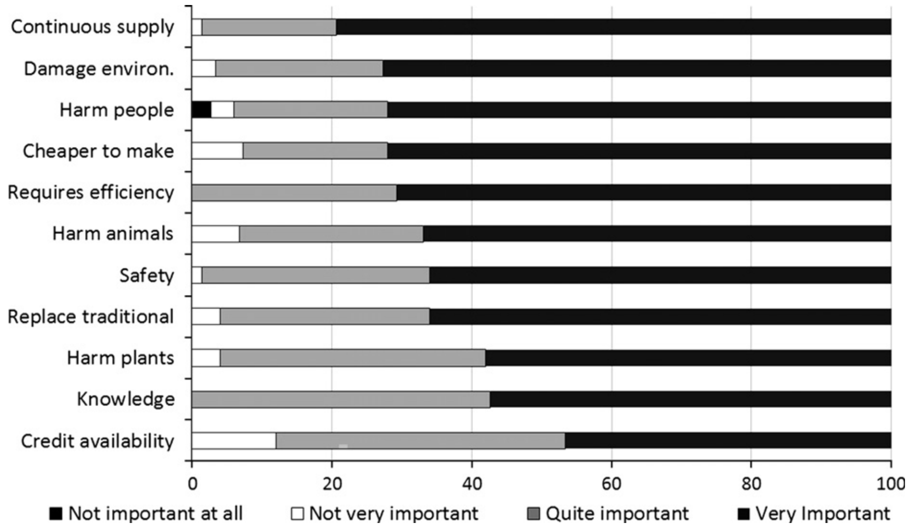


Fig. 3. Perceptions and ideas about the characteristics of renewable energy.

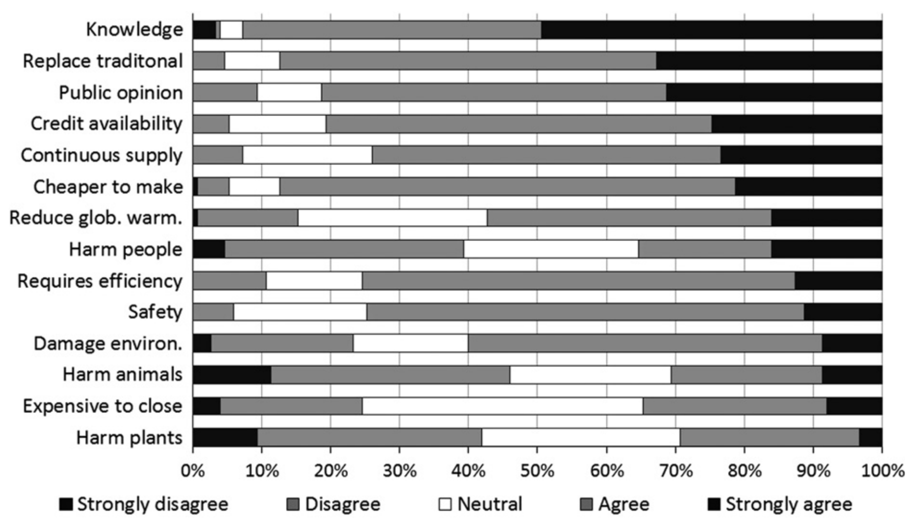


Fig. 4. Views about the importance of various characteristics of energy production.

warming). As for the harm of renewable energy generation facilities to people, 16% 'strongly agreed', 19% 'agreed', 26% took a 'neutral' stance, 35% 'disagreed' and 5% 'strongly disagreed' with this statement (Harm people). About 13% of the sample 'strongly agreed' and 63% 'agreed' on the point that they needed to increase their energy consumption efficiency to viably use renewable energy (Requires efficiency). Regarding the comparative safety of renewable energy facilities, 11% 'strongly agreed' and 63% 'agreed' that they are safer than other types of energy generation facilities (Safety). The perception of respondents on potentially harmful effects from renewable energy sources that have not yet been discovered, was less homogenous, resulting in a 9% share for 'strongly agree', 51% for 'agree', 17% who were 'neutral' and 21% for 'disagree' (Damage environment). The respondents′ ideas about the harm done by renewable energy sources to animals was the following: 9% 'strongly agreed', 22% 'agreed', 24% took a 'neutral' position, 35% 'disagreed' and 12% 'strongly disagreed' with the statement (Harm animals). Some 55% 'agreed' that post-use processes of renewable energy sources are expensive and hazardous (Expensive to close). About 29% were 'neutral' and 33% 'disagreed' with the statement that renewable energy sources may harm plants (Harm plants).

3.2. Views about the importance of various characteristics of energy generation

Fig. 4 illustrates the respondents′ views about the importance of several characteristics of energy generation. The results are ordered from the highest to the lowest share of responses corresponding to 'Very important' (on the right-hand side). Thus, the black right-hand bar shows the share of the respondents who rated the given characteristics as 'very important', the next gray bar represents the share of 'quite important' and the white bar denotes those who thought the statement 'not very important'. The black left-hand bar (where available) corresponds to those respondents judging the statement to be 'not important at all'. A very high share of respondents found the characteristics they were asked about to be either very important or quite important.

The black right hand-side bar shows the share of the respondents who thought the given characteristics to be 'very important', the next gray bar represents the share of those who thought them to be 'quite important'. The white bar gives the share of the respondents judging a certain characteristic as 'not very important' and the left-black bar (where available) corresponds to those thinking the factor to be 'not important at all'.

Apparently, continuous supply seemed to be the most important characteristic to many respondents, with scores of 80% for 'very important and 19% for 'quite important'. They also seem to be concerned about the potential environmental damage that electricity generation in general might cause, with some 73% judging this to be 'very important' and 24% 'quite important'. As for the threat from electricity generation in general to people, 72% thought it was 'very important' and 22% thought that it was 'quite important' to have energy sources that would not harm people. The statement that electricity should be cheap was judged to be 'very important' by 72% and 'quite important' by 21% of the respondents. Regarding efficient use of electricity, 71% of the sample thought it to be 'very important' and 29% 'quite important'. The harm caused by electricity generation to animals was found to be 'very important' by 67% of the people polled and 'quite important' by 26%. The safety of electricity generation was found to be 'very important' by 66% of respondents and about 33% said it was 'quite important'. Switching to renewable energy sources in the households was 'very important' for 66% of the respondents. 58% of the people polled thought it 'very important' and 38% 'quite important' that electricity generation should not harm plants. The statement concerning knowledge of the availability and reliability (in terms of continuous supply) of energy sources, was seen by 57% of the respondents to be 'very important and 43% thought it 'quite important'. Finally, the availability of credit and loans for making the transition to renewable energy sources; respondents judged this statement to be 'very important' by 47%, 'quite important' by 42% and 'not very important' by 12% of the respondents.

3.3. Homogeneity of responses

A cluster analysis based on the Ward method showed that the respondents′ age and livelihood do not largely affect the homogeneity of their choices. It also revealed that the respondents can be categorized into two groups on distance 8 based on the answers to questions of the Section B and C. Group 1 includes 70 respondents and Group 2 includes 80 respondents. The mean age of Group 1 is one year less than that of Group 2, while Group 2 also has 10% more female respondents than Group 1. Group 2 also has slightly more respondents living in a rural area. Respondents in Group 1 experienced an average of 11.5 h of electricity shortages during a week, while those in Group 2 reported an average of 10 h of weekly electricity cut-offs. The share of respondents willing to live close to a renewable energy facility was 6% higher in Group 2; however, the share of people who have seen an operating renewable energy facility was higher in Group 1. Also, respondents in Group 1 considered themselves to be more concerned and informed about global warming.

The respondents′ views about the importance of various characteristics of energy generation in general were highly homogenous, while their perceptions and expectations about renewable energy sources varied significantly in some cases. Although the overall results demonstrated people′s high interest and belief in renewable energy, relative deviations from the trends were also considered.

Some 9% of the respondents in Group 1 disagreed with the statement about the role of knowledge in renewable energy penetration, while Group 2 did not contain any such respondents. However some 80% of Group 1 considered renewable energy sources to deliver uninterrupted electricity supply, while in Group 2 only 72% of people thought so. Some 70% of the respondents in Group 1 were concerned about possible harm from the renewable energy sources while only 50% percent voiced concerned in Group 2. Some 94% of Group 1 believed that renewable energy sources could replace the traditional energy sources in the households while this belief was shared by 82% of respondents in Group 2. As for the post-use utilization complexity of the renewable energy sources, 20% of the respondents do not agree and 39% agree in Group 1 and in Group 2 only 8% people disagree and 34% agree on the point.

Group 2 seems to be more environmentally concerned and hence cautiously optimistic (or pessimistic), while Group 1 seems to be significantly more optimistic based on their responses.

3.4. Incentives and disincentives for application of renewable energy sources

Following the reasoning of Kılınç et al. [14], if a certain characteristic of renewable energy was considered as positive and this same characteristic was found to be very important according to the perception of the respondents, the combination of these beliefs could be considered as an incentive for renewable energy application. Likewise, if the opposite was true, if the respondents′ common views on certain characteristics were found to be negative and rated 'very important', then the combination of these beliefs could serve as disincentive. When the respondents′ common views were either positive or negative towards a certain characteristic, and if they judged this specific characteristic to be less important, then this characteristic was assumed to have no influence in decision making related to renewable energy application. For example, if the general perception on "Electricity generated with renewable energy sources is cheap compared to other sources" (Question 2 Category B) was found to be "Strongly agree", and general perception on "How important is it to you that electricity does not cost too much?" was "Very important" then the "cheaper to make" factor serves as a disincentive.

In order to explore this in a quantitative way, responses were given relative strength values as illustrated in Table 1. The relative strength values are based on a basic scaling denoting 0 for neutral and allow calculating the average values of each pair of characteristics. From these values, the mean scores of the respondents′ perception on each characteristic of renewable energy and their views about the importance of each characteristic were calculated. The products of the mean of perception of each characteristic and means of their importance yielded a quantitative explanation of whether the characteristics should be treated as an incentive or disincentive (Table 1).

Table 1
Comparative strength of responses and their mean indexes.

Response	Score	Response	Score
Strongly agree	+1.0	Very important	1.00
Agree	+0.5	Quite important	0.66
Neutral	0	Not very important	0.33
Disagree	−0.5	Not important at all	0.00
Strongly disagree	−1.0		
	Mean of perceptions	**Mean of importance**	**Mean index**
Knowledge	0.67	0.85	0.58
Replace traditional	0.58	0.87	0.50
Cheaper to make	0.51	0.88	0.45
Continuous supply	0.45	0.93	0.42
Credit availability	0.50	0.78	0.39
Safety	0.40	0.88	0.35
Requires efficiency	0.39	0.90	0.35
Damage environment	0.21	0.90	0.19
Harm people	0.04	0.88	0.03
Harm animals	−0.09	0.87	−0.08
Harm plants	−0.09	0.84	−0.08

All the characteristics were found to be very important while the most important of them were continuous supply and achieving efficiency. As for the potential harm of renewable energy facilities to plants and animals, respondents disagreed with the statement in general while they neither agreed nor disagreed on the potential harm to people. The issue of having sufficient knowledge regarding renewable energy sources, their potential to replace both natural gas and non-renewably generated electricity and the issue of the "cheaper to make" factor of renewable energy were found to be the most important incentives.

4. Discussion

The penetration of renewable energy sources in residential electricity generation in the developing countries is a central question of emissions reduction and combating global warming. Central Asian countries, with relatively higher technical potential [16], have more favorable prospects for renewable energy implementation compared to most Western European countries, where the share of renewable energy in total energy generation is already the highest in the world. While Central Asian countries continue to expand their energy sector with vastly available traditional energy sources, global warming and the need for decreasing anthropogenic emissions place the necessary gradual transition to sustainable energy sources in the near future. With a significantly high share in energy consumption, residential consumers would be a good starting point for this transition. Hence, the objective of the present study was to explore the people's perceptions about the characteristics of renewable energy and their importance, with its aim of determining the possible incentives and disincentives for renewable energy penetration.

Transition to sustainable energy sources is important in the context of global warming and reducing anthropogenic emissions. About 25% of respondents claimed to know a lot about global warming and 60% indicated that they possessed some knowledge of global warming, which is very reasonable, bearing in mind the immense worldwide attention which is given to the subject. Kılınç et al. [14] have also observed that at least two-thirds of the population in most other studies claimed to know at least something about global warming. In the present study, about 55% of the respondents agreed that they were ready to pay a premium for electricity from a renewable source and 54% of the respondents claimed that they were confident that global warming is actually happening, which also supports their claim of having some knowledge of the latter.

Nevertheless, the analysis of the survey results revealed that in Uzbekistan, where traditional energy prices are quite low, the desire for individual energy independence could serve as the foremost driving force behind residential renewable energy penetration. Electricity cut-offs or shortages persist in Uzbekistan due to old distribution infrastructure in remote rural areas, or in places where there is a need for reduced energy consumption due to high distribution losses, poor distribution management and illegal energy tapping. Since the same problem exists with the centralized gas supply, people seek individually independent energy systems. The respondents strongly agreed that renewable energy sources could replace traditional sources and it was very important to them that renewable energy sources could completely meet all of their household energy needs. Renewable energy sources are, therefore especially preferred when they can replace both centralized natural gas and electricity supplies in households. However, creating such an off-grid independent energy system requires much higher capital investment, especially in the case of windmills or photovoltaic systems, since households require more energy for heating and cooking than lighting and appliance utilization, as is currently the case.

Although most of the people have no firsthand experience with any renewable energy sources, they assumed that renewable energy source installation is not affordable for them. Therefore, people considered the availability of credit or loans for renewable energy source installation to be very important. Considering the fact that residential renewable energy installations are credited everywhere, including in Western economies with the highest per capita gross national income, the concern of the Uzbek people seems to be appropriate.

Again, although respondents did not have firsthand experience with renewable energy sources, they held quite prominent views about various renewable energy sources. They had both negative and positive perceptions towards certain aspects. Most respondents were positive about the characteristics of "knowledge" (or education about the available sources), ability to replace traditional sources, the effect/role of public opinion in renewable energy application, and credit (availability of external financing). Negative characteristics were a potential threat to plants and animals and the need for special post-use disposal (post-use utilization). The respondents were confident that renewable energy in general is safer than other types of energy sources. However, they were concerned about any potential environmental impact of renewable energy sources that has not yet been discovered due to mankind's shorter experience with them, as an opposed to traditional energy sources.

As for the harm caused by renewable energy sources to animals and plants, it was very important for the respondents that their energy should be produced in a way that does not harm both categories, but they disagreed with the statement that renewable energy sources harm either of them. As for the harm caused by renewable energy sources to people, respondents neither agreed nor disagreed with the statement.

Concerning the importance of price, it was very important for the respondents that their electricity is cheaper and they strongly agreed that electricity produced with renewable energy sources is cheaper compared to other sources. Of course it can be argued that renewable energy sources require higher capital investment and hence, the electricity produced with them cannot possibly be cheaper than that produced by traditional sources. However, this can be explained by the fact that according to the popular idea, once installed renewable energy sources require almost no operation and maintenance costs and hence, produce "free energy". This is to some extent true only for solar and wind sources while biogas and biomass resources involve costs for operation and maintenance.

The respondents thought it very important that their electricity consumption would be more efficient and agreed that application of renewable energy source requires higher efficiency for smaller investment costs and improved cost-recovery. Energy efficiency, for example the use of fluorescent bulbs, has been promoted in Uzbekistan through the mass media for the last two years and people are aware that there is an enormous energy saving potential in their households.

Regarding the need for sufficient knowledge on application and utilization of renewable energy sources, people are interested to find out what renewable energy sources are available to them, how are the technical feasibility of these resources and which of these renewable sources can best meet their needs without creating unexpected environmental problems. Respondents' views on the need for sufficient knowledge might also be explained by their concern about whether there are enough skilled technicians that can install and maintain these sources properly. This might especially be appropriate for biogas facilities, where higher standards of professionalism and technical safety are required [17].

5. Conclusion

This study revealed that any need for renewable energy sources at the present time exists mainly due to the cut-offs or shortages in the traditional energy supply. The cut-offs and shortages in the system are caused by old infrastructure, high distribution losses and poor distribution management as well as illegal energy tapping. The solution for these problems requires significant investment and time. Therefore, the state could focus more on crediting residential renewable energy applications, which was found to be another important incentive for renewable energy penetration.

Increasing public awareness concerning renewable energy sources and their potential was found to be another aspect of creating favorable preconditions for their application. The acquisition of sufficient knowledge was found to be the most important aspect respondents agreed on. Furthermore, capacity building and availability of qualified technical personnel seem to be very important.

Actions towards promoting public awareness of the potential of energy conservation also create favorable conditions for renewable energy penetration. Increased public awareness on the safety of renewable resources, when compared to other types of energy generation facilities in term of emissions, would also serve as an incentive.

Bearing in mind the fact that energy transition is inevitable for Uzbekistan during the next two decades and also the need for reforms in energy generation, distribution and consumption, it seems to be a most appropriate time to launch a transition to renewable energy sources in the residential sector, where most of the characteristics of renewable energy promise to serve as an incentive. In line with creating a continuous supply and transition to sustainable energy generation with a promising future, this switch would also help in reducing anthropogenic emissions and combating global warming.

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Appendix A. The Questionnaire

The front-page of the questionnaire included some brief information about the study. The confidentiality of the data gathered was also mentioned. The respondents filled out the questionnaire under the supervision of the interviewer.

QUESTIONNAIRE IN ENGLISH

Section A: General information

A1. Age: A2. Sex: (M) Male, (F) Female
A3. Location of home:(1) Urban (2) Rural
A4. Would you be willing to pay more for electricity from a renewable source (solar, wind, biomass or biogas)
(1) Yes (0) No
A5. Would you be willing to pay more for electricity from a renewable source if everyone else did?
(1) Yes (0) No
A6. Would you be willing to live close to a renewable energy power plant (photovoltaic power plant, wind turbines, biomass or biogas power plant)?
(1) Yes (0) No
A7. How many hours a week do electricity cut-offs occur in your neighborhood? _____h/week
A8. Have you ever seen an operating renewable energy facility in your neighborhood?
(1) Yes (0) No

Section B: Perceptions about various characteristics, advantages and disadvantages of renewable energy generation

B1. Substantial knowledge on the application of renewable energy (solar, wind, biogas, biomass) is required for its successful application in the household.
B2. Electricity generated with renewable energy sources is cheap compared to other sources.
B3. Credit/loans are necessary for household renewable energy application.
B4. Electricity from renewable sources is more reliable in terms of continuous supply.
B5. Renewable energy facilities harm/disturb the people in their surroundings.
B6. Renewable energy facilities harm/disturb animals in their surroundings.
B7. Renewable energy facilities harm/disturb plants in their surroundings.
B8. Renewable energy facilities are safer compared to other types of power stations.
B9. Since renewable energy sources are a relatively new type of energy, we do not have enough experience to come to a conclusion about the long term impact of renewable energy sources on the environment.
B10. For higher cost effectiveness, renewable energy requires improved energy conservation measures.
B11. Renewable energy sources are capable of phasing out the traditional energy sources in households in the future.
B12. The production and post-use process of a renewable energy facility is hazardous.
B13. Global warming would be reduced if more of our electricity was generated from renewable energy sources.
B14. Most of the people I know are not familiar with renewable energy sources and their benefits.

Section C: Perceptions about the importance of various characteristics of power generation in general

C1. How important is it to you that people need to know more about the various aspects of the energy options available to them?
C2. How important is it to you that electricity does not cost too much?
C3. How important is it to you that the state/bank supports your energy supply/transition decision?
C4. How important is it to you that your electricity supply is reliable and continuous?
C5. How important is it to you that the energy facility supplying you with energy would not harm/disturb the people in their surroundings?

C6. How important is it to you that the energy facility supplying you with energy would not harm/disturb the animal in their surroundings?
C7. How important is it to you that the energy facility supplying you with energy would not harm/disturb the plants in their surroundings?
C8. How important is it to you that your energy supply is from a technically safer source? (from a hydropower station instead of a nuclear station)
C9. How important is it to you that all possible environmental threats of your energy supply be clear in advance without any uncertainty?
C10. How important is it to you to apply energy saving measures in your household?
C11. How important is it to you to switch to sustainable energy sources?

Section D: Perceptions about global warming

D1. How worried are you about what global warming might do to the environment?
D2. How much do you think you know about global warming?
D3. How 'environmentally friendly' do you think you are? (How much do you think you 'take care of' the environment by the things you do?)
D4. Do you think that global warming is really happening now?

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